Exploration of the Relationship between Chronotype and Performance in a New Zealand Student Population

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Abstract

Contemporary literature suggests circadian rhythm has a significant effect on performance for evening chronotypes in secondary and tertiary education. This study conducts a survey on university students (n = 39) to determine chronotype distribution and compare with other nations. The study demonstrates similar results in comparison with other nations and suggests further research on strategies to mitigate the chronotype based performance discrepancy. The performance aspect of the research (n = 20) hypothesized that morning types will perform better in the morning (compared to evening types) and evening types will perform better in the afternoon (compared to morning types). Analysis of the relationship appeared with non-significant support to the hypotheses. It is expected that further research on this area my gain guidance from this study, and may benefit the learning prospects of New Zealand students.

Exploration of the Relationship between Chronotype and Performance in a New Zealand Student Population

The present study is designed to understand the chronotype distribution in a New Zealand student sample and explore the relationship between individual chronotype and performance. In particular, how well students perform in a gamified health and safety assessment in the morning or late afternoon. In recent researches, it has been suggested that the early start times associated with current schooling hours can be detrimental to the performance of students identified as evening chronotypes. The research has shown that evening chronotype students often achieve lower school grades, when attending class or taking exams in the morning, in comparison to their morning counterparts

Current research suggests the difference in performance may be explained by evening chronotypes having to accommodate societal hours, rather than adhering to their natural hours of sleep. This discrepancy in natural hours of sleep and societal hours is referred to in research as social jet lag, and believed to be caused by the evening types having a phase delay, or later onset in comparison to other chronotypes, of melatonin, the hormone believed to be responsible for the activation of functions that lead to sleep. This melatonin onset phase delay paired with a need to adhere to social hours, leads to sleep loss in the morning period for evening chronotypes, which often accumulates as the week progresses, is referred to as accumulated sleep debt. Accumulated sleep debt has been observed to negatively affect *performance*, wellbeing and health, creating a need for research and understanding in the area.

The present study first aims to provide additional knowledge regarding the chronotype distribution in the research participants. Findings in this area could provide useful information concerning whether there might be a need to alter the student workday toward a later start time to enable a more equal learning opportunity for all chronotypes, as this has been shown to have

a positive effect on the performance of evening chronotypes and no adverse effect on morning chronotypes.

The present study then seeks to further understand the relationship between morning and evening chronotype's and performance. This is an attempt to understand if the performance of chronotypes differs in the morning or evening and to compare the performance of morning chronotypes to evening chronotypes. This will be attained by collecting data regarding chronotype groups performance at the start and end of work/schooling hours. The hypotheses:

Hypothesis 1: Morning chronotypes would perform better in the morning than evening chronotypes.

Hypothesis 2: Evening chronotypes would perform better in the afternoon than morning types.

Furthermore, the present study attempts to bridge the gap between the schooling environment and the workplace environment through the use of a workplace environment test of performance. This research could be considered as a pilot study to help understand the factors involved if further research is to be undertaken regarding the relationship between chronotype and performance in a workplace setting.

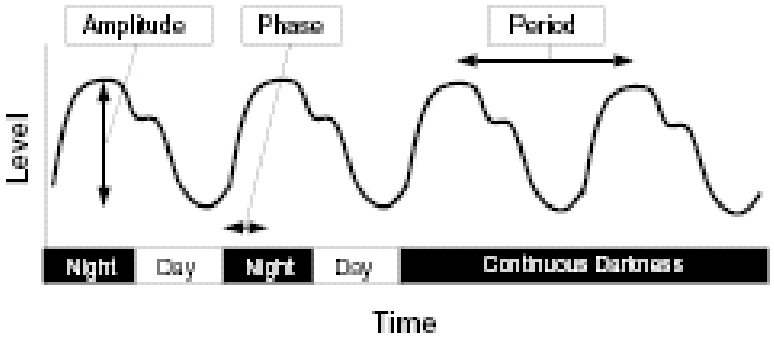
What is Chronotype (Circadian Rhythm) and Morningness-Eveningness

Many people have heard or used the term ‘lark’ or ‘night owl’ at some point, but what does it actually mean? Why is someone an ‘early’ bird (lark) or a ‘night’ owl? In psychology literature, the terms morningness-eveningness are used to describe the different chronotypes, circadian rhythms or circadian typology, in reference to the individual’s preference for timing of sleep and wake. According to Horne and Östberg (1976), individuals can be classified into morning (lark), evening (owl), or neutral types, using a chronotype questionnaire such as the morningness-eveningness questionnaire (MEQ).

Differences in chronotype have been observed in individuals since the 1930’s beginning with the work of Freeman and Hovland. However, it wasn’t until several decades later that Aschoff and Wever demonstrated that the variability observed was related to the human circadian system (Adan & Natale, 2002). The variability in circadian rhythms is posited to be a result of the phase and amplitude of individuals biological rhythms as demonstrated in Figure 1.

Figure 1

An Example of Circadian Rhythm Phase and Amplitude for Demonstration Purposes



Circadian Rhythm Phase and Amplitude. Adapted from Vitaterna, et al. (2001).

Research by Itzek-Greulich et al., (2016), explains evening types as individuals who exhibit circadian rhythm phase-delay, resulting in a tendency tend to go to bed and get up late, and often reach peak performance, cognitively and physically, in the late afternoon and evening. In comparison morning types are individuals who exhibit a phase-advance, displaying an inclination to go to bed earlier and rise earlier, tending to prefer the morning hours for physical and intellectual activity. Intermediate types being in an intermediate position. In research terms, the circadian functions of morning-type individuals present a phase advance, in comparison to evening-types exhibiting a phase delay, the intermediate-type phase being in an intermediate position (Adan & Natale, 2002).

In short, morningness-eveningness refers to the chronotype displayed by the individual, and chronotype refers to the sleep-wake patterns displayed by the individual as a result of their biological circadian rhythm. The term circadian, which originated from Franz Halberg', translates in Latin to "circa" -about and "dies" -a day, in reference to biological rhythms having a period of 'about a day' (Liddle, 1966; Wittmann et al., 2006).

Research by Wittmann et al. (2006), found that the circadian rhythm will persist even during temporal isolation experiments, with a period of about twenty-four-hours. This was further evidenced through research which found people living under the same environmental conditions and with similar daily activities present rhythmic variations that differ (Adan & Natale, 2002). Fischer et al. (2017), describes the chronotype as the individual's reflection of how the circadian system is embedded into the twenty-four-hour day, with rhythms in cognition, physiology and behaviour occurring later or earlier than others.

Whilst Oginska (2011), considers chronotype as the individual fitting in to the world's rhythmicity, with a theory that chronotype may be considered an element of the individual's personality. Oginska's position is explained by the individual differences in chronotype being

similar to that of other personality traits i.e. the range found in the big five, and therefore chronotype could be considered in the same category. With the research and data collected from around the world tending to indicate similar chronotype distribution as shown in Table 1, there is no reason not to consider chronotype as an individual factor worthy of similar consideration when analysing the individual as a patient or as a job applicant etc. This understanding of the individual's biological rhythm could help in hiring for shift work, when building teams and possibly in the alteration of organisation work hours to suit all chronotypes.

Systematic Research of Chronotypes

Systematic surveys of chronotype didn't really commence until the last quarter of the 1900's (Ogińska, 2011), with what is considered the pioneering tool in self-reported sleep measures, the Morningness-Eveningness Questionnaire (MEQ), developed in 1976 by Horne and Östberg, This was followed by other scales which include: the Diurnal Type Scale Torsvall and Åkerstedt (1980); the Composite Scale by Smith et al., (1989); the reduced version of the MEQ by Adan and Almirall (1991); the Preference Scale by Smith et al., (2002); and the Munich Chronotype Questionnaire by Roenneberg et al., (2003). However, the tool most frequently used, and well known due to its high validity and reliability, is the MEQ, which is why it is used in the present study.

Understanding the Determinants and Biology of Circadian Rhythms

Circadian rhythms are shown to exist in many biological functions in humans, from sleep/wake cycle and physiology (body temperature, melatonin and cortisol), to gene expression (Wittmann, Dinich, Merrow & Roenneberg, 2006). Circadian rhythms are believed to be determined by both genetic and environmental factors, and considered by most researchers in the area to be mostly of an endogenous nature, or of predisposing biological or

genetic influences (Kerkhof & Van Dongen, 1996; Adan & Natale, 2002; Zavada et al., 2005; Ogińska, 2011; Smarr & Schirmer, 2018).

Environmental factors believed to influence the determination of the chronotype include climate, longitude and latitude, and entrainment to light (Ogińska, 2011; Roenneberg & Merrow, 2014). Climate is evidenced through research by Randler (2017), which found significant results regarding self-reported chronotypes and distance to the equator, with populations closer to the equator and resulting warmer climates (Mexico, Guatemala, Philippines and India) reporting higher numbers of individual's who perceive themselves as morning orientated, in comparison to populations who live further from the equator and in resulting cooler climates (England, United States, Russia and Ireland).

Longitude and latitude may be explained by people living closer to the equator, experiencing a stable light-dark cycle throughout the year. In contrast, for countries further away from the equator including New Zealand, Finland, Canada and other cooler climates, people experience daylight savings, where clocks are turned back one hour in autumn and forward one hour in spring (Arrona-Palacios & Díaz-Morales, 2018). This alteration of the clock results in fluctuations in light-dark cycles, and subsequent interruptions in sleeping patterns, which can lead to sleep loss and sleep debt.

Research regarding the genetic influences on circadian rhythm suggests heritability is a one of the major influences on chronotype: This is evidenced by heritability estimate studies involving twins and family's which suggest that genetic factors explain a considerable proportion, up to 50%, of the population variability in circadian timing (Kalmbach et al., (2017). Additionally, age is believed to be a factor when analysing the chronotype of the individual, as the morningness-eveningness orientation is believed to change significantly during the individual's life span (Itzek-Greulich et al., 2016). Research suggests, younger age children (kindergarten and preschool) are more orientated to the morning but turn toward

eveningness during adolescence, reaching a maximum in 'lateness' around the age of twenty (Roenneberg et al., (2004). They explain that after reaching their maximum 'lateness', humans become progressively more morning orientated as they age. These findings suggest that students, often of an age associated with adolescents and young adults, are reaching their maximum 'lateness' or beginning the progression to morningness, whilst attending university classes and undertaking exams. For evening chronotypes this means their sleeping schedule is interrupted in the morning hours, resulting in sleep debt. So why don't people just go to sleep earlier?

Melatonin, the Onset of Sleep and Sleep Debt

The onset of melatonin is considered as one the best markers for the onset of sleep in humans. Research suggests the onset of endogenous melatonin secretion in the nighttime occurs approximately two hours before the individual's onset of sleep, evidenced by melatonin levels in the blood stream (Pandi-Perumal et al., 2005; Scheer & Czeisler, 2005; Blask, 2009; Zisapel, 2018; Kun et al., 2019). It is believed that melatonin affects the individual's propensity to sleep by inhibiting the mechanisms that generate wakefulness (Pandi-Perumal et al., 2005; Scheer & Czeisler, 2005). Furthermore, the absence of endogenous melatonin production is associated with a decrease in sleep quality (Scheer & Czeisler, 2005).

These findings suggest that without the onset of melatonin, the individual is not likely to feel the need for sleep due to the occurrence of wakefulness mechanisms. Therefore, going to bed is not likely to be productive of sleep until the onset of melatonin. Yet evening chronotypes often still need to adhere to social hours for work, meaning they need to get up in periods where their circadian rhythm would usually have them sleep, which results in less sleep than is required. This loss of sleep results in sleep debt, the cumulative hours of sleep loss with

respect to the individuals daily need for sleep, which is correlated with many detrimental outcomes including health, wellbeing and performance (Van Dongen et al., 2003). The present study is focusing on the performance aspect and the relationship between chronotype and performance.

Performance Definition

Work psychology literature defines task performance as "the proficiency with which incumbents perform activities that are formally recognized as part of their jobs" (Viswesvaran & Ones, 2000). For the performance task used in this research, a gamified assessment of safety behaviours in the form of a forklift simulation has been employed. This has been conducted to measure the action of participants regarding health and safety matters which may hold great concern into that specific environment. More information on this regard are readily available at the UC library.

Recent researches on this particular area are mostly focusing the grades of the student participants as performance indicator. The present study approaches to provide a better understanding of the effect on performance in an environment similar to the workplace. This has been realised by resembling the start and finish times of the workplace, by applying a performance assessment which replicates a real workplace environment.

Current Theory Regarding Chronotypes Relationship with Performance

Research on chronotypes by Taillard et al., (2011), indicates evening types who are forced to keep a schedule outside of their preferred sleep schedule, express higher subjective sleepiness and lower alertness, which correlates with lower workplace productivity, higher risk of ill-health, and a higher health and safety risk.

Research regarding adolescent's circadian rhythms, indicates a need in schools to shift start-finish times, to ensure adolescents get enough sleep so they may achieve optimum growth, both physically and cognitively, (Roeser, Schlarb & Kübler, 2013). This is evidenced through research over the last eighteen years which indicates that students who are identified as evening types often achieve lower grades in school then their morning counterparts (Giannotti et al., 2002; Roenneberg et al., 2003; Zerbini et al., 2017; Jankowski, 2017; Arrona-Palacios & Díaz-Morales, 2018; Smarr & Schirmer, 2018). This is believed to be because evening types who are sleep restricted by attending morning classes are shown to exhibit decreased ability to learn and retain presented materials, perform decision-making tasks, and actively participate in class (Roenneberg et al., 2003; Arrona-Palacios & Díaz-Morales, 2018).

Research suggests delaying school times for adolescents by 20 to 85 minutes had positive effects which included decreased sleepiness in the daytime; increased overall attendance; improved cognitive performance, school grades, mood, academic functioning, and health; and lower rates of depression (Arrona-Palacios & Díaz-Morales, 2018). Western school schedules often tend to be optimised for earlier chronotypes with the 8/9am start and 3/4pm finish. However, this leaves later chronotypes at greater risk of persistent social jet lag in relation to their environment. This persistent jetlag appears to result in decreased academic performance (Smarr & Schirmer, 2018), and is highly correlated with academic performance.

In some countries, schools utilise a double shift school system. The school operates in two shifts, with a group of students arriving early in the morning and leaving around midday, while another group arrives around midday and leaves in the evening. The research for these schools' reports that morning types performed better and achieved better grades in the morning classes than evening types. However, in the afternoon classes there was no significant difference between the results of the different chronotypes (Arrona-Palacios & Díaz-Morales, 2018). Additionally, evening type students who took exams in the morning had poorer grades

than morning types, however this discrepancy was found to disappear in the afternoon exams with no significant difference found in the performance between morning and evening chronotypes (Itzek-Greulich et al., 2016).

To understand the possible effect on the New Zealand population, should adopting a similar strategy be considered, the chronotype distribution of several other nations is shown in Table 1. This information enables an understanding of the similarities or differences in global chronotype distribution. These chronotype distributions, when compared with the distributions found in the present study, could enable a more informed decision for the alteration of secondary and tertiary schooling hours, based on population distribution similarities, or as a pilot study for further exploration into the area of New Zealand population chronotype distribution.

Table 1

Comparison MEQ Scores from Several Nations

Country	Morning	Intermediate	Evening
Germany (n=28)	18%	68%	14%
Portugal (n=354)	11%	71%	18%
Brazil (n=103)	15%	61%	24%

The MEQ scores shown in Table 1 includes research on a Brazilian university population (Messora, et. al, 2017); German university population (de Punder et al., 2019); and Portuguese university population (Meira et al., 2015). These studies were chosen for their recency using the University of Canterbury Library Database.

In summary, the present study aims to understand the chronotype distribution in a New Zealand university sample, and to understand how that distribution compares to other nations.

Similarities in chronotype distribution could provide necessary evidence for the adoption of similar practices that have displayed a positive effect on the learning performance of evening chronotypes, such as a delay in start times, or the adoption of a double-shift system. This research will then attempt to better understand the relationship between chronotype and performance, whilst considering the effect of gaming experience on the performance task. This could enable a better understanding of the effects of the current work hours on different chronotypes within a workplace and provide a starting point for further studies in the area of chronotype and workplace performance.

Method

Overview

Participants were required to take the Morningness-Eveningness Questionnaire (MEQ), and then randomly assigned to attend either the morning or the evening session first. They were first given a survey regarding their sleep patterns (not used in this analysis), and then a performance task in the form of the Safety Behaviour Test (SBT). Upon completion the participants were invited to the second session, within the following two weeks, where they again first took the sleep activity survey, followed by the performance task, and an additional gaming experience survey accompanied by an invitation to receive the research report.

Demographics including sex (male, female, or gender diverse), year of birth and ethnicity were collected for analysis purposes, however, ethnicity was not used as a factor in this analysis. This research and experiment were reviewed and approved by the University of Canterbury Human Ethics Committee, reference number HEC 2019/92.

Participants

This study used a mixed convenience style of recruitment due to the access to a large number of participants. First year psychology students were invited to participate in the research using the university's research invitation system and offered (3) course credits in return for participation. Later the recruitment was opened to other students in the Applied Psychology Master's program to make up necessary numbers for analysis. For the purposes of this study we have classified participants as either morning or evening, splitting intermediate types by score into the morning or evening category. This was done to accommodate a shortage of participant numbers in the moderate to definite morning and evening categories, rather than omitting their results from the analysis.

In total 43 people signed up for the chronotype test and to join the study, of which 4 were incomplete data (n= 39, 28 Females, 11 Male, 0 Gender Diverse; Chronotype: 19 morning, 20 evening). Of those 39, referred to as "All", twenty people (n= 20, 15 Females, 5 Males, 0 Gender Diverse; Chronotype: 8 morning, 12 evening) aged 18-25 (mean 20.75) finished both performance tasks and submitted data. This participant group is referred to as "Sample". All statistical analyses are performed using SPSS for windows, version 25.

Materials

Materials used in this study include the Morningness-eveningness questionnaire (MEQ), the safety behaviour test (SBT), and a survey of individuals self-reported experience with gaming survey.

Chronotype

Morningness-Eveningness Questionnaire (MEQ) by Horne and Östberg (1976). A 19-item self-report questionnaire used to determine the morningness-eveningness of the individual. Questions are multi choice and preferential, with the participant answering when they would prefer to get up rather than when they actually get up and rated on a 4-point scale. The MEQ, attached in Appendix C, includes questions such as "During the first half hour after you wake up in the morning, how tired do you feel?" and "At approximately what time of day do you usually feel your best?". Each question is assigned equal value with the score ranging from 16 to 86. Lower values indicate evening types. The reported reliability (Cronbach α = 0.83), and validation with oral temperature curves, indicates a valid and reliable tool.

A change was made with the categorisation of the MEQ to accommodate the participant numbers: the intermediate types were separated into morning and evening types based on their

score, with intermediate evening types being in the 42 – 50 score range and intermediate morning types being in the 51- 58 score range shown, in Table 2.

Table 2

The Dichotomous Morning/Evening Scores and Chronotype Scores Based on the MEQ

Chronotype score range			Chronotype secondary score range
1	Evening	16 - 50	1 16 - 30 = definite evening,
2	Morning	51 - 86	2 31 - 41 = moderate evening,
			3 42 - 50 = intermediate evening
			4 51 - 58 = intermediate morning,
			5 59 - 69 = moderate morning,
			6 69 - 86 = definite morning

Performance

The Safety Behaviour Test (SBT) (Used as the performance test) is considered a gamified assessment of safety behaviour. In the assessment, participants play through the eyes of "forklift driver number 1", a forklift driver in a waste disposal warehouse. The player is asked to use a forklift, and to load items into a shipping container. It is an animated three-dimensional point and click assessment, which involves the player clicking on objects in the assessment to interact with them. The tasks involve the participant navigating pathways and delivering goods to a container, while being subjected to health and safety challenges. These challenge points include but are not limited to putting on protective equipment, spills, robotic arms, other employees, lowering barrier arms and following directional arrows.

Throughout the process of delivering goods the container, the player will be faced with 34 decision points, some are simple decisions (e.g., opening a door), however, 13 are about

safety where the participant has the option to make either a safe, or an unsafe decision. For the processing of the performance data each decision held equal weighting and the participant was given a score out of 34. This score was calculated to give a percentage of correct actions taken, and this percentage was the performance score used for the analysis of performance.

Gaming Experience

Previous studies indicated the gaming experience of the individual could have an adverse impact on the SBT score (Burt et al., 2018). This was evidenced by experienced gamers showing significantly higher SBT scores compared to those who have no gaming experience. To control for this adverse impact, data was collected which could enable an understanding of the individuals experience.

The gaming experience questionnaire consisted of three questions:

1. How much time did you spend last week playing video and/or computer games?

Participants were required to enter a number of hours: 0-9 = 0, 10-20 = 1, 20+ = 2

2. Do you like to play video and/or computer games?

Five-point scale: Never played, not at all = 0, not really, somewhat = 1, very much = 2

3. How often do you play?

Four-point scale: Semesterly, monthly = 0, weekly = 1, daily = 2

The scoring for each question was a 0, 1, or 2, with a maximum score of 6 for the three questions. Higher scores in this measure, indicate higher experience in gaming. The scoring was then dichotomised for analysis, with those participants scoring a total of 0-2 classed as having no experience, and the participants who scored 3-6 classed as experienced.

Procedure

Participants were invited to join the research as part of their requirements in introductory psychology classes, which requires participation in research for course credit. Other participants were sourced from the Applied Psychology master's program to make up needed numbers, this recruitment was done via Facebook group messaging. All participants who signed up were sent an invitation via email to take the MEQ via Qualtrics online survey system, which included the data release permission form. Using the MEQ the participants chronotypes were calculated and recorded. The chronotypes were then simplified into two categories: morning and evening.

The participants were randomly assigned into attending either the morning or the evening session first. The participants were asked to undertake the performance task on two separate occasion, on the same day of the week, but in different weeks. This required the participants to either attend a lab session overseen by the researcher, or to do the task and surveys from home via a personal computer. The performance tasks were undertaken once in the morning, between 8am and 10am, and once in the evening, between 4pm and 6pm. These times were used to mirror the start finish times of the workday, but with allowances of the individuals personal schedule.

For the first performance task, the participants were asked to fill out a quick survey which involved collecting information regarding sleepiness and sleep behaviour (not used in this analysis). Following the survey, the participants were asked to complete the SBT performance task. Upon finishing the performance task, the participants were reminded they would need to attend another session in the following 2 weeks and asked to commit to a time within the specified hours. An email reminder was sent to the participant on the day before the

participant was scheduled to attend or undertake the performance task, at both time one and time two.

For performance task time 2 the participants undertook the same survey and performance task as they did in the first session, with the addition of a second survey, which consisted of a short gaming experience questionnaire and an opportunity to opt in to receive a summary of the research once completed. The results were collated in excel, with any necessary coding or calculations undertaken, and then exported to SPSS.

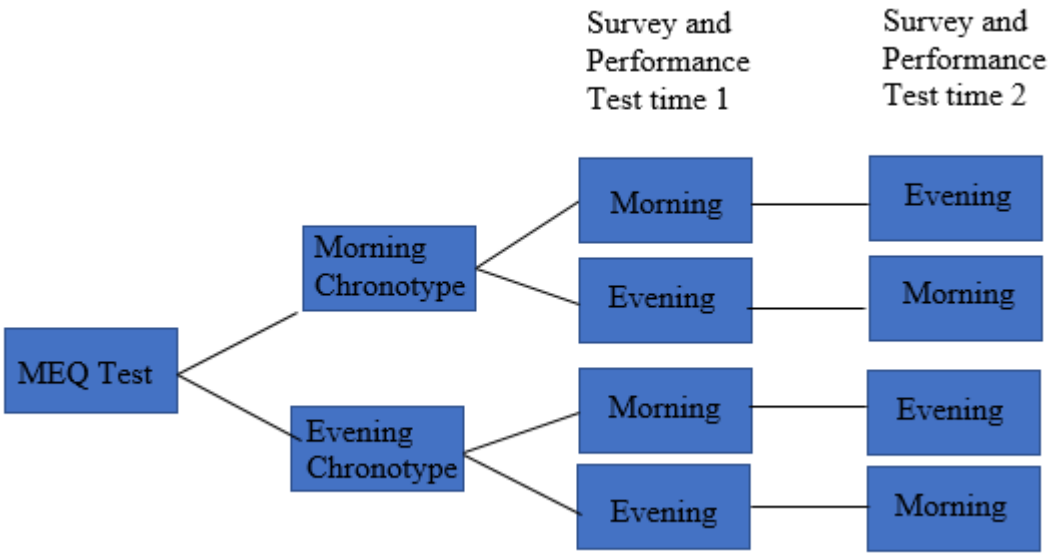
Design

This research uses a within-between subject's design for the data collection and a repeated measures ANOVA for the data analysis. The design for the study is reported in Figure 2. The data collection for the MEQ was sent out at the time the participant signed up for the research, which in some cases was weeks before the research took place, to allow for scheduling and other necessary bookings etc.

Participants undertook the MEQ chronotype test, were consequently separated into morning or evening type based on their results, and then randomly assigned to the morning or evening (test time 1). The participants were then asked to attend the second session (test time 2) in the following weeks on the same weekday as time 1. Data from the participants' morning and evening session were compared (between) and then compared against participants from the other chronotypes (within).

Figure 2

Study Design



Results

This research attempted to understand the chronotype distribution in a New Zealand University population, and the relationship between chronotypes, sleep and performance in conditions that mimic a workplace time schedule. The research hypothesised that participants who were identified as morning chronotypes would perform better in the morning timeslot than the afternoon timeslot, and better in the morning than evening type chronotypes. To test this involved collecting chronotype data using the Morningness/Eveningness Questionnaire (MEQ) and performance data using the SBT, and then conducting, using SPSS, a repeated measures ANOVA to determine any statistical differences in performance. The following information includes the population distribution, the performance data, and control variables for gaming experience.

Research question: Understanding the Chronotype Distribution in a New Zealand University Sample.

This section describes the distribution of chronotype scores, and other data collected using the MEQ. Data was collected from a New Zealand university population, specifically from students enrolled at the University of Canterbury in undergraduate introductory psychology and Master of Applied Psychology. The results of the MEQ, when segregated into morning and evening types, indicates a relatively even distribution (morning chronotype = 49%), as shown in Table 3. The table is separated by those who signed up for the research and completed all necessary steps referred to as “Sample”, and those who signed up for the research, completed the MEQ but chose not to complete some or all of the required steps, referred to as “All”.

Table 3

Study Recruitment Numbers and Chronotype Distribution

Chronotype	N	Morning	Intermediate	Evening
Signed up for study (All)	39	8 (20.5%)	19 (49%)	12 (30.5%)
Completed all study requirements (Sample)	20	5 (25%)	10 (50%)	5 (25%)

MEQ scores shown in Table 4, indicate a higher number of participants in the intermediate range (49%), followed by the moderate range, with the definite morning and evening showing only one score in each of the categories.

Table 4

Distribution of MEQ Scores

Chronotype		Total sample (n=20)	Total All (n=39)
1	16 - 30 = definite evening,		1 (2.5%)
2	31 - 41 = moderate evening,	5 (25%)	7 (18%)
3	42 - 50 = intermediate evening	7 (35%)	12 (31%)
4	51 - 58 = intermediate morning,	3 (15%)	7 (18%)
5	59 - 69 = moderate morning,	5 (25%)	11 (28%)
6	69 - 86 = definite morning		1 (2.5%)

Hypothesis 1 and 2. Performance scores for Morning and Evening Performance Sessions

This section attempts to understand the relationship between chronotype and performance, with a control variable of gaming experience. The performance data is a score of the correct actions taken by the participant while undertaking the performance task, divided by the number of opportunities for correct actions (34) to give an overall percentage.

Table 5, shows the participant numbers, mean scores and standard deviations for the morning and evening performance, separated by chronotype.

Table 5

Descriptive Statistics for Morning and Evening Performance Sessions

	Chronotype	Mean	Std. Deviation	N
Morning perf.	Evening	.6616	.11471	12
	Morning	.6743	.12521	8
	Total	.6667	.11591	20
Evening perf.	Evening	.6618	.13155	12
	Morning	.7160	.08561	8
	Total	.6835	.11603	20

The results of the repeated measures ANOVA, for the test of within subjects did not indicate significant difference between the means for the morning or evening time performance scores ($F(1,18) = .335$, $p = .569$). Furthermore, the results for the test of between subjects for morning or evening chronotype did not indicate significant differences ($F(1,19) = .568$, $p = .461$).

Controlling for Gaming Experience

Previous studies using the SBT indicated that gaming experience may be a factor in the analysis. To balance this effect, data was collected about the individual's experience with computer games. To measure this variable, questions were taken from a gaming experience questionnaire, specifically those questions which pertained to the level of gaming experience of the individual. As shown in Table 6, 25% of participants had medium to high levels of gaming experience, with the rest of the participants indicating little or no gaming experience. These five participants were coded as one and the rest coded as zero to enable this variable to be used as a control.

Table 6

Distribution of Gaming Experience for Participants

		Frequency	Percent	Cumulative Percent
Valid	No to little experience	15	75.0	75.0
	Medium to high experience	5	25.0	100.0
	Total	20	100.0	

The results of the repeated measures ANOVA for performance scores in the morning and evening, with gaming experience as a covariate, indicate no significant difference ($F(1,17) = .096$, $p = .761$).

Controlling for Learned Effect

The performance information for participants at time 1 and time 2 was collected, as shown in Table 7, to understand if the performance significantly changed at time 2. If the participants did exhibit significantly higher scores this would indicate that the participants learnt from the first experience and this would likely have an effect on the results. This score allows us to understand if an effect existed prior to the alteration of the performance scores into morning session and evening session.

Table 7

Descriptive Statistics for the Performance Data Collection at Time 1 and Time 2

	Mean	Std. Deviation	N
Performance time 1	.64250	.123405	20
Performance time 2	.70760	.097913	20

The results of a repeated measures ANOVA for performance scores taken at time 1 and time 2 indicate a significant result ($F_{1,19} = 6.685$, $p = .018$). This significant result indicates that performance at time 2 was significantly better than performance at time 1. This is a good indication that the participant learnt the test at time 1, and that the learning lead to higher results in time 2.

Discussion

Previous research indicated that lark's, or morning chronotypes, were a minority in society, yet current work and schooling hours are designed to accommodate their preferred hours for performance. Furthermore, these hours are suggested to be consequential to evening chronotypes performance, health and wellbeing, believed to be due to the associated loss of sleep for evening types in the morning, resulting in accumulated sleep debt. The present study sought to obtain information regarding the chronotype distribution in a New Zealand university sample, in order to understand if this could be an area of concern. Also, to add to the limited knowledge regarding chronotypes in a New Zealand population. This research may act as a pilot study for the collection of chronotype data from a much larger and more representative population sample.

The present study also attempts to better understand the relationship between chronotype and performance. Recent research suggests evening chronotypes perform worse than morning types in morning tests of performance, with no significant difference shown between chronotypes in afternoon tests of performance (Itzek-Greulich et al., 2016). Findings in this area could provide valuable information toward the alteration of schooling hours as recommended by Arrona-Palacios & Díaz-Morales (2018), and perhaps provide direction for research into the effects of work times, in an attempt to accommodate the peak performance of all chronotypes.

Chronotype distribution

The chronotype information for the New Zealand student sample was collected using the MEQ. The MEQ results indicate a higher percentage of morning chronotypes and a lower percentage of intermediate types, in comparison to the other nations shown in Table 8, which

included Brazil, Germany and Portugal. Specifically, the present study indicated a 10% higher distribution in the morning categories and a 10% lower distribution in the intermediate categories.

Table 8

Comparison MEQ Scores from Several Nations Including New Zealand

Country	Morning	Intermediate	Evening
New Zealand (n=39)	30.5%	49%	20.5%
Germany (n=28)	18%	68%	14%
Portugal (n=354)	11%	71%	18%
Brazil (n=103)	15%	61%	24%

The chronotype distribution differences found between this study and studies in other nations, may be explained by the proportion of gender (72% female), and the age (Mean = 23, range 19–42) of the participants in this sample. Research regarding gender found girls and women tend to score higher on chronotype scales (Chelminski, et al., 1997; Randler, 2007; Adan and Natale, 2009), which is indicative of morning orientation.

Previous chronotype research with student populations indicates that the individual's age, and associated development stage may cause the distribution to skew toward the intermediate type (Hagenauer, et al., 2009). This may be explained by students often attending university after high school, which is associated with the period of development from adolescent to adulthood. This period of development means some students circadian rhythms may not have matured into morning or evening, thus a higher distribution in the intermediate range in comparison to the general population (Hagenauer, et al., 2009). It is therefore possible that the age range found in this study resulted in fewer cases in the intermediate range.

When comparing the age range as well as the proportion of female participants, we offer a plausible explanation for the higher percentage of morning chronotypes and lower percentage of intermediate chronotypes than is found in the studies reported in Table 1. The age range means more chronotypes are fully developed, minimising the intermediate types, and the higher percentage of female participants is an indication of higher morning type scores.

Regardless of the discrepancies in the chronotype distribution data collected in this sample, the results of the MEQ posit evening (30.5%), and intermediate (49%) chronotypes as a majority in comparison to morning chronotypes (20.5%). The similarities in chronotype distribution for our sample suggests the alteration of start/finish times for New Zealand universities by one to two hours, or the adoption of a double shift system, could result in similar benefits demonstrated in research by Itzek-Greulich et al. (2016), who report that morning types achieved better grades than evening types in classes taught in the morning but not in classes taught in the afternoon.

Performance and Chronotype Relationship

The present research posited two hypotheses regarding the relationship between chronotype and performance:

Hypothesis 1: Morning chronotypes would perform better in the morning than evening chronotypes.

Hypothesis 2: Evening chronotypes would perform better in the afternoon than morning types.

To test these hypotheses, the performance test results were tested by applying a repeated measures ANOVA that calculated the difference within the means for the morning and evening sessions, and between the sessions for the two chronotypes (morning or evening). The results

of this analysis did not indicate a significant effect for the between test. This indicates that the participants did not perform significantly better in the morning session compared to the evening session. Furthermore, the results of the within analysis did not indicate a significant difference within the session, meaning neither the morning nor evening chronotypes performed better. Therefore, hypothesis 1, was not supported, and hypothesis 2 was not supported.

This indicates, for a New Zealand student sample, using the dichotomous Morning-evening categorisation adapted from the MEQ, which included intermediate types, neither morning types nor evening types performed better on the SBT in the morning. Furthermore, neither morning nor evening types performed better in the afternoon.

Regarding the gaming experience of the individual as a covariate, in previous studies was shown to have an adverse impact on the SBT score, with experienced gamers showing significantly higher scores compared to those who have no gaming experience (Burt et al., 2018). To control for this adverse impact, data was collected which enabled an understanding of the individuals experience. However, when gaming experience was used as a covariate in the repeated measures ANOVA, the results did not change (i.e., were not significant). This indicates that gaming experience did not have an adverse impact on the SBT results for this sample.

In designing the experiment, measures were taken in an attempt to control for learned effect, or the participants improving significantly between time 1 and time 2 due to memory and experience. This was done by spacing out the time between performance test one and test two by a minimum of seven days, and having the participants attend the morning or evening session first, chosen randomly. The repeated measures ANOVA results for performance time 1 and time 2 indicate a significant effect. This indicates we can reject the null hypothesis and

deduce that participants performed better at time 2 in comparison to time 1. However, this does indicate that learned effect is likely a factor in the performance scores.

For sample size, an a priori power analysis was conducted using G*Power3 (Faul et al., 2007), to test the difference between two independent groups means using a two-tailed test, a low effect size (d = .25), and an alpha of .05. The result indicated that total a sample size of 36 would be sufficient to achieve a power of .95. The present study originally recruited 39 participants, believed to be a sufficient amount to reach a conclusive analysis. However, only 20 participants completed all the required steps for performance analysis, therefore the sample size was inadequate, and could have affected the results.

Another factor that may have led to the results is the use of intermediate types separated by MEQ score into morning or evening types. Due to the small sample size of volunteers for this part of the present study (n=20), there were not enough participant numbers in the moderate and definite morning or evening categories to conduct a thorough analysis. To overcome this, the three categories (morning, intermediate, evening) specified by Horne and Östberg (1976), were reduced to two: morning or evening, by MEQ score as shown in Table 2. The resulting inclusion of the intermediate types, rather than exclusion, has possibly affected the means of the performance scores.

Lastly, for the tools used it is possible that the SBT, a gamified assessment of health and safety behaviours, is not a relevant measure of performance in a university student population. This test is designed to measure the health and safety behaviours of an employee in a working environment, it is highly possible the participants do not have experience working in a transport and logistics environment. Furthermore, it is unlikely the participants have been trained to be mindful of health and safety, unlike most employees who would have received some form of training during their induction into this environment. This may have influenced

the participants overall scoring, with experienced or semi experienced people in this environment creating outlying scores.

Limitations/Recommendations

Because other studies using a similar population in other countries reported significant findings, the non-significant results in the present study may be explained by one of or a sum of the limitations experienced, which include but are not limited to: the dichotomisation of the MEQ scores, sample size, and the chronotype measure used.

Due to the size of the sample needed for analysis, rather than remove or analyse the intermediate types separately, the original categories proposed by the Horne and Östberg were adapted, and the intermediate types were incorporated into the morning and evening categories. If further study or research is to be undertaken in this area, the incorporation of intermediate types is not recommended. Instead the recruitment of a much larger pool of participants than is recommended for the analysis, will enable the researcher to analyse only identified morning or evening types, or analyse intermediate types as their own group. This will enable a more thorough understanding of the specific chronotypes relationship with performance then was achieved through the inclusion of intermediate types.

The sample size used in the present study is most likely the major cause for the differences reported in this study compared to other studies. The smaller sample meant controlling for outliers, controlling for gender, and analysing only morning and evening types were not valid options, as they would remove cases from the sample and would likely affect the analysis.

In explanation, the shortage of participants was not considered until it became clear there would not be sufficient numbers. When advertisement via the universities research

participation system began, the current enrolment for the classes was around 600. Also, given the number of people who had completed the MEQ section, there was confidence that there should be more than enough participants to enable a thorough analysis. There was no anticipation of the number of participants (49%) who would not complete all of the required steps for the performance analysis. When the closing date for participation in the research was apparent, and it became clear that the current sample would not enough for the analysis, the researcher attempted to minimise the shortage of participants by recruiting other students in the APSY program. It is recommended to use a much larger sample size, and have a better understanding of the number of participants that could be expected to sign up, including how many will participate to completion.

In measuring the chronotype, originally, the study was going to use both the MEQ and the Munich Chronotype Questionnaire (MCTQ). Whilst the MEQ is good for classification of chronotypes, the MCTQ provide a bigger range of data, including information regarding sleep debt and social jetlag, which when measuring performance and chronotype, should be factors that are taken into consideration, given their effect on the individual and the individuals performance. However, for the present study, due to the amount of questions and time needed to answer the overall survey, the MCTQ was removed. In review, the MCTQ or a combination sleep behaviour/chronotype tool would be a better overall tool for capturing a wider range of data, including social jetlag and sleep debt, which would allow for a more thorough analysis on the influencers of performance.

Lastly, this research was attempting to bridge the gap between the performance of the student in university, to the performance of a participant in a study designed to mimic aspects of the workplace. The effect of chronotype on workplace performance is an area of research that has not received a lot of attention to date, hopefully this study may act as a pilot or provide direction for further research that benefit both organisations and employees. We work for the

majority of our lives, why shouldn’t we explore ways to make work more comfortable and enjoyable, especially if these solutions provide positive results for performance and satisfaction.

Conclusion

The chronotype distribution for this New Zealand student sample came up with similar results to that of other nations. The study experience suggests demonstrating such research as it has been evidently found successful. This pilot study suggests collection of chronotype data first. To be more specific, a large sample size will be more effective to establish a detailed understanding on chronotype distribution. Replication of the study in further research may come up with success as the current approach demonstrated promising results (even including the delay of schooling start times by 20 to 85 minutes, or the adoption of a double-shift system).

For the hypotheses, morning types will perform better in the morning (compared to evening types) and evening types will perform better in the afternoon (compared to morning types). However, the results of the performance tests did not support. Furthermore, there are several factors which may have confounded the data. This includes the sample size, the dichotomisation of the chronotypes categories (to be inclusive of intermediate types), and the relevance of the test performance with the population being studied. Further research in this area may benefit from: the use of a much larger sample size, specific analysis of only morning and evening chronotypes, the inclusion of sleep debt and social jetlag data, and a performance test more relevant to the experience of the population being studied. The exploration of the relationship between chronotypes and performance in the workplace or in a workplace setting may result in outcomes beneficial to organisation’s and their employees.

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Appendix A. Information sheet.

My name is Aidan McCarthy and I am an Applied Psychology Masters student at the University of Canterbury. I am conducting research on the effects of chronotypes (diurnal preference) and sleep patterns, on performance.
Thank you for your interest in this study. If you choose to take part, your involvement will involve filling out a survey, and undertaking two performance related exercises, which should take approximately one hour to one and a half hours in total. The completion of the survey and both of the performance exercises will be met with a reward of two (2) course credits.

Participation is voluntary, and you have the right to withdraw at any stage without penalty, you can do this by exiting the survey at any stage and not completing the performance tasks. You may ask for your raw data to be returned to you or destroyed at any stage. If you withdraw, I will remove information relating to you. However, once analysis of raw data starts on the 1st September 2019 you will no longer be able to withdraw your data from the study.

If at any stage during the survey you have any feelings of distress, you may go to the following for support:

UC Health Centre
Located at the rear of the UCSA carpark beside The Foundry bar.
Phone: +64 3 369 4444

The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation: your identity will not be made public. To ensure confidentiality, your identifying information will be transferred into a code on a separate spreadsheet. Once data collection has been completed at both time one and time two, all identifying information will be destroyed. Data will be securely stored on the university servers in password protected files on password protected computers. Only myself and my supervisor's, will have access to the raw data. After five years, all raw data will be destroyed. The completed research in the form of the thesis is a public document and will be available through the UC Library.

If you wish to receive a copy of the report of the summary of the study findings, you can contact myself at the conclusion of this project or follow the prompts at the end of the Qualtrics survey.

The project is being carried out as a requirement for the completion of a Master's in Applied Psychology by Aidan McCarthy under the supervision of Professor Katharina Näswall who can be contacted at Katharina.naswall@canterbury.ac.nz. Professor Näswall will be pleased to discuss any concerns you may have about participation in the project.

This project has been reviewed and approved by the University of Canterbury Human Ethics Committee, and participants should address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz

Appendix B. Consent form.

Department of Psychology
Telephone: +64 22 048 2132
Email: aj.mccarthy@pg.canterbury.ac.nz

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Relationship between diurnal preference and performance in New Zealand university students.
Consent Form for Survey Participants

Include a statement regarding each of the following:

- I have been given a full explanation of this project and have had the opportunity to ask questions.
- I understand what is required of me if I agree to take part in the research.
- I understand that participation is voluntary, and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.
- I understand that any information or opinions I provide will be kept confidential to the researcher and that any published or reported results will not identify the participants. I understand that a thesis is a public document and will be available through the UC Library.
- I understand that all data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after five years. [
- I understand the risks associated with taking part and how they will be managed.
- I understand that I can contact the researcher AJ McCarthy or supervisor Katharina Näswall for further information. If I have any complaints, I can contact the Chair of the University of Canterbury Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)
- I would like a summary of the results of the project.
- **By checking this box, I indicate my agreement to participate in the project under the conditions outlined above**

Appendix C. MEQ

For each question, please select the answer that best describes you by circling the point value that best indicates how you have felt in recent weeks.

1. Approximately what time would you get up if you were entirely free to plan your day?

[5] 5:00 AM–6:30 AM (05:00–06:30 h)

[4] 6:30 AM–7:45 AM (06:30–07:45 h)

[3] 7:45 AM–9:45 AM (07:45–09:45 h)

[2] 9:45 AM–11:00 AM (09:45–11:00 h)

[1] 11:00 AM–12 noon (11:00–12:00 h)

2. Approximately what time would you go to bed if you were entirely free to plan your evening?

[5] 8:00 PM–9:00 PM (20:00–21:00 h)

[4] 9:00 PM–10:15 PM (21:00–22:15 h)

[3] 10:15 PM–12:30 AM (22:15–00:30 h)

[2] 12:30 AM–1:45 AM (00:30–01:45 h)

[1] 1:45 AM–3:00 AM (01:45–03:00 h)

3. If you usually have to get up at a specific time in the morning, how much do you depend on an alarm clock?

[4] Not at all [3] Slightly [2] Somewhat [1] Very much

4. How easy do you find it to get up in the morning (when you are not awakened unexpectedly)?

[1] Very difficult [2] Somewhat difficult [3] Fairly easy [4] Very easy

5. How alert do you feel during the first half hour after you wake up in the morning?

[1] Not at all alert [2] Slightly alert [3] Fairly alert [4] Very alert

6. How hungry do you feel during the first half hour after you wake up?

[1] Not at all hungry [2] Slightly hungry [3] Fairly hungry [4] Very hungry

7. During the first half hour after you wake up in the morning, how do you feel?

[1] Very tired [2] Fairly tired [3] Fairly refreshed [4] Very refreshed

8. If you had no commitments the next day, what time would you go to bed compared to your usual bedtime?

[4] Seldom or never later

[3] Less than 1 hour later

[2] 1-2 hours later

[1] More than 2 hours later

9. You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week, and the best time for him is between 7-8 AM (07-08 h). Bearing in mind nothing but your own internal "clock," how do you think you would perform?

[4] Would be in good form

[3] Would be in reasonable form

[2] Would find it difficult

[1] Would find it very difficult

10. At approximately what time in the evening do you feel tired, and, as a result, in need of sleep?

[5] 8:00 PM–9:00 PM (20:00–21:00 h)

[4] 9:00 PM–10:15 PM (21:00–22:15 h)

[3] 10:15 PM–12:45 AM (22:15–00:45 h)

[2] 12:45 AM–2:00 AM (00:45–02:00 h)

[1] 2:00 AM–3:00 AM (02:00–03:00 h)

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last two hours. You are entirely free to plan your day. Considering only your "internal clock," which one of the four testing times would you choose?

[6] 8 AM–10 AM (08–10 h)

[4] 11 AM–1 PM (11–13 h)

[2] 3 PM–5 PM (15–17 h)

[0] 7 PM–9 PM (19–21 h)

12. If you got into bed at 11 PM (23 h), how tired would you be?

[0] Not at all tired [2] A little tired [3] Fairly tired [5] Very tired

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which one of the following are you most likely to do?

[4] Will wake up at usual time, but will not fall back asleep

[3] Will wake up at usual time and will doze thereafter

[2] Will wake up at usual time, but will fall asleep again

[1] Will not wake up until later than usual

14. One night you have to remain awake between 4-6 AM (04-06 h) in order to carry out a night watch. You have no time commitments the next day. Which one of the alternatives would suit you best?

[1] Would not go to bed until the watch is over

[2] Would take a nap before and sleep after

[3] Would take a good sleep before and nap after

[4] Would sleep only before the watch

15. You have two hours of hard physical work. You are entirely free to plan your day. Considering only your internal "clock," which of the following times would you choose?

[4] 8 AM–10 AM (08–10 h)

[3] 11 AM–1 PM (11–13 h)

[2] 3 PM–5 PM (15–17 h)

[1] 7 PM–9 PM (19–21 h)

16. You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week. The best time for them is between 10-11 PM (22-23 h). Bearing in mind only your internal "clock," how well do you think you would perform?

[1] Would be in good form

[2] Would be in reasonable form

[3] Would find it difficult

[4] Would find it very difficult

17. Suppose you can choose your own work hours. Assume that you work a five-hour day (including breaks), your job is interesting, and you are paid based on your performance. At approximately what time would you choose to begin?

[5] 5 hours starting between 4–8 AM (04–08 h)

[4] 5 hours starting between 8–9 AM (08–09 h)

[3] 5 hours starting between 9 AM–2 PM (09–14 h)

[2] 5 hours starting between 2–5 PM (14–17 h)

[1] 5 hours starting between 5 PM–4 AM (17–04 h)

18. At approximately what time of day do you usually feel your best?

[5] 5–8 AM (05–08 h)

[4] 8–10 AM (08–10 h)

[3] 10 AM–5 PM (10–17 h)

[2] 5–10 PM (17–22 h)

[1] 10 PM–5 AM (22–05 h)

19. One hears about “morning types” and “evening types.” Which one of these types do you consider yourself to be?

[6] Definitely a morning type

[4] Rather more a morning type than an evening type

[2] Rather more an evening type than a morning type

[1] Definitely an evening type

_____ Total points for all 19 questions

INTERPRETING AND USING YOUR MORNINGNESS-EVENINGNESS SCORE

This questionnaire has 19 questions, each with a number of points. First, add up the points you circled and enter your total morningness-eveningness score here:

Scores can range from 16-86. Scores of 41 and below indicate "evening types." Scores of 59 and above indicate "morning types." Scores between 42-58 indicate "intermediate types."

16-30	31-41	42-58	59-69	70-86
definite evening	moderate evening	intermediate	moderate morning	definite morning